Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

At a somewhat lower temperature it remained alive and virulent forty-eight days. Whether longer, will be reported upon the completion of the work. This table indicates plainly how sensitive this particular organism is to a very slight difference of temperature.

PINE WOOD INFECTED WITH PLAGUE CULTURE.

Another series of tests was made with splinters of pine wood about the size of a match stick. They were sterilized and soaked in a three-day-old bouillon culture of plague and then placed in Petri dishes which were kept in the laboratory (20° to 27° C.), cool chamber (17° to 19° C.), and the dark room (20° to 23° C.), with the following results:

Pieces of pine wood inoculated with bouillon culture of bacillus pestis.

Time.	Laboratory.	Cool chamber.	Dark room.	Time.	Laboratory.	Cool chamber.	Dark room.
4 days	x	x	x	13 days	—	—	—
8 days	—	x	x	18 days	—	—	—
11 days	—	—	x	21 days	—	—	—

Note.—x indicates growth. — indicates no growth.

The same culture was used to impregnate the pieces of pine wood as was used for the squares of crash in the preceding table, and these two objects thus infected were exposed to precisely the same conditions. It may therefore be assumed that the organism lives a shorter time on the one than on the other.

PAPER INFECTED WITH PLAGUE CULTURE.

Another series of tests was made with pieces of filter paper and pieces of glazed (sized) paper. This paper is cut into little squares and sterilized and impregnated in the usual way with a three-day-old bouillon culture of the organism. These pieces were placed in Petri dishes and kept in the desk in my office where the temperature ranges from 20° to 27° C. The results follow:

Plague culture dried on paper.

Time.	Filter paper.	Glazed paper.	Time.	Filter paper.	Glazed paper.
4 days	x	x	13 days	—	—
8 days	x	x	18 days	—	—
11 days	—	—			

Note.—x indicates growth. — indicates no growth.

On account of the importance of this subject, a summary of the literature follows:

Kitasato [a] found the organism alive after four days when dried on a glass cover slip and kept at 28° to 30° C. It grew after one to thirty-six hours, but not after four days. He used the pus of buboes from man. His experiments with serum cultures gave similar results. He was the first to study this question.

---

[a] Preliminary notice of the bacillus of bubonic plague, Hongkong, July 7, 1894.

WILM (*a*) found the organism alive after four and one-half days on a glass slip. He exposed pure cultures at a temperature of 29° to 31° C. He could obtain no growth in bouillon after an exposure of four and one-half days. In vacuo, the bacilli were killed after an exposure of three hours.

R. ABEL (*b*) used pure cultures from bouillon, agar-agar and blood serum, or pus from the peritoneal cavity of guinea pigs, containing the bacillus pestis. These were planted on various objects—glass cover slips, silk, wool, woolen cloth, linen, and pieces of ox skin, and in sterile earth. Also pieces of the organs, liver, and spleen of animals dead of plague were dried. Approximately similar sizes were taken every day from each object. The result of these experiments showed that the manner of drying influenced the viability of the pest bacillus. No matter on what material, the result of drying at the temperature of 35° C. in the incubator, or 20° C. in vacuo over sulphuric acids, the bacillus was always found dead in two, or at most, four days. If the drying was permitted at the room temperature, 16° to 20° C. in a dark place, the bacilli remained alive much longer and the material in which they were dried markedly influenced the result.

On cover slips they remained alive six to nine days, from pus and cultures. Only once in four tests were the bacilli found alive a longer time—fourteen days—but not longer than this.

On threads of various sorts, on linen, and in pieces of organs, the bacilli were found alive after thirty days; if longer, it could not be determined, because the work was interrupted. In the longer exposures the threads planted in bouillon and kept undisturbed showed the outgrowth of isolated colonies here and there, indicating that many of the bacilli had lost their power of multiplication.

He, therefore, concluded that forced drying at a temperature over 30° C. or by substances that have a high affinity for water such as concentrated sulphuric acid, the bacillus pestis dies quickly. Slower drying at lower temperature is less harmful. However, even at room temperature the quicker drying, such as on a cover glass, is more harmful to the bacillus than the slower drying on pieces of cloth or in pieces of tissue.

" The fact that the bacillus remains alive longer when dried at 16° to 20° C. than was at first announced, teaches that in our climate (Hamburg) at least, we can not expect the organism to quickly disappear in clothing, etc."

On fresh skin the bacillus was found alive after ten days. These tests

---

a Uber die Pestepidemic in Hongkong im Jahre, 1896. Hygienische Rundschau, 1897, Bd. VII, page 290.

b Zur Kenntnis des Pestbacillus. Centralblat fur Bakteriologie und Parasitenkunde, etc., Bd. XXI, 1897, page 497.

were not altogether satisfactory because the sterilizing of the skin before infecting it with pest was not successful after washing, and eight days' immersion in ether and alcohol. It is possible that the bacilli are alive after ten days, though not demonstrable on account of the growth of other organisms.

Further tests are being made with cultures, and the bacillus in blood and organs placed on various objects, and kept under various conditions, report on which will be submitted later.

MARTIN FICKER (*a*) tested the effect of drying and moisture alternately applied on the viability of the plague bacillus and found it to be more harmful than simple drying. He found that changing the conditions from dryness to moisture caused the death of the organism in twenty to twenty-eight hours, while the same in the desiccator lived eight or nine days.

He used twenty-four hour old cultures from agar-agar plates and made thin spreads on cover glasses by means of the platinum œse. Moisture was added twice daily. The cover glass was planted in bouillon and in case growth appeared this was plated out on gelatin.

	Alternate moisture.		Desiccator.	
	†	O	x	O
	Hours.	*Hours.*	*Days.*	*Days.*
Culture 24 hours	20	28	8	9
Do	24	36	9	11
Culture 36 hours	36	48	11	12

This demonstrates that cultures die more rapidly in drying when moisture and dryness are alternated.

BATZAROFF (*b*) has been able to demonstrate that even in the dry state the pest organism remains living and virulent a long time. The organs of an animal dead of pest, as well as cultures mixed with infusorial earth, are subjected to desiccation in vacuo at "room temperature."

From time to time a piece of the dried substance is tested by grinding in a sterilized mortar, and the powder thus obtained is introduced in small amounts into the nose of an animal. The results of these experiments, which are indicated in the subjoined table, show that the virus of pest supports desiccation for a long time very well when it is in an albuminous medium, as the pulp of the spleen or any other organ. Under such conditions it attenuates very slowly; in fact, in the first two or three weeks scarcely at all. On the other hand, if it is not protected, as in the case of dried cultures in infusorial earth, its virulence diminishes rapidly, so that in three weeks, inoculated into the nose of animals, the dried cultures produced no morbid effect.

---

a Zeitschrift fur Hygiene, Bd. XXXIX, 1898, page 25.

b La Pneumonie Pesteuse Experimentale. Annales de l'Institut Pasteur, May, 1899, page 392.

Plague-pneumonia produced by nasal inoculations of dried virus.

Splenic pulp.		Dried cultures in infusorial earth.	
Duration of desiccation.	Duration of sickness.	Duration of desiccation.	Duration of sickness.
	Days.		*Days.*
5 days	4½	2 days	7
8 days	4	5 days	6½
12 days	4½	7 days	(*a*)
14 days	5	19 days	12
20 days	4½	31 days	(*a*)
26 days	4½		
30 days	6½		
33 days	6½		
38 days	6½		
44 days	(*a*)		

a Resisted.

HANKIN (*b*) states that as far as his researches go they tend to show that the bubonic microbe, whether derived from cultures or the organs of deceased animals, and whether placed in cotton, or sheep's wool, or gunny cloth, uniformly die out in six days. He states, however, that owing to the fact that epidemiological evidence tends to show that clothing may in rare cases convey the infection he is unwilling to draw any definite conclusions from his researches at present.

THE GERMAN PLAGUE COMMISSION (*c*), (Gaffky, Sticker, Pfeiffer, Dieudonné) used the organism from agar-agar, and bouillon cultures; also sputum from plague-pneumonia, peritoneal exudate from guinea pigs, etc. This infectious material was placed on various objects, as glass, silk threads, filter paper, fabrics, earth, etc., and permitted to dry. The plague-infected objects were placed in Petri dishes and put in a dark corner of the laboratory to dry out. As a rule, the infected pieces were turned over from time to time to hasten the drying.

The temperature of the laboratory during these experiments was about 29° to 31° C. The objects were well protected from the light. Some were kept in an improvised ice box, in which the temperature was about 22° C. and the air saturated with moisture. The proof that the organism was still alive could, unfortunately, only be made by inoculation of mice and not by means of cultures. Small pieces of the infected objects were taken from time to time and placed under the skin of a mouse. The following are the results:

---

b The plague in India, 1896, 1897, Vol. II, appendices I to T, page 10, *et seq.*

c Deutsche Pestkommission. Kaiserlichen Gesundheitsamtes, Bd. 16. Berlin, 1899, page 274, *et seq.*

Infected with pure culture.

Object.	Temperature.	Longest time in days the organism lived.
Glass	30° to 32° C.	3
Glass in desiccator	do	1
Filter paper	do	3
Filter paper in desiccator	do	1
Silk thread	do	5
Silk thread in desiccator	do	1
Piece of silk	do	6
Piece of silk in desiccator	do	1
Piece of wool	do	6
Piece of wool in desiccator	do	2
Large piece of linen	do	7

Infected with plague organs.

Object.	Temperature.	Longest time in days the organism lived.
Glass	30° to 32° C.	2
	22° to 24° C.	2
Filter paper	30° to 32° C.	2
	22° to 24° C.	2
Silk thread	30° to 32° C.	2
	22° to 24° C.	2
Piece of wool	30° to 32° C.	6
	22° to 24° C.	6
Large piece of gauze	30° to 32° C.	6
	22° to 24° C.	6
Large piece of linen	30° to 32° C.	6
	22° to 24° C.	8

Sputum from plague-pneumonia.

Object.	Temperature.	Longest time in days the organism lived.
Glass	30° to 32° C.	1
Silk thread	do	3
Piece of wool	do	6

Pus from bubo.

Object.	Temperature.	Longest time in days the organism lived.
Glass	30° to 32° C.	6
Silk thread	do	1
Piece of wool	do	1

Peritoneal exudate from plague-infected guinea pig.

Object.	Temperature.	Longest time in days the organism lived.
Silk thread	29° to 31° C.	
Filter paper	do	
Piece of silk	do	(*a*)
Piece of wool	do	
Glass tube	do	(*b*)

a Still virulent on the second day.
b Dead on the seventh day.

The longest observation made by the commission on the viability of the plague bacillus was therefore eight days.

It made no difference whether cultures one to two days' old, or eight-day-old cultures were used, as far as the resistance to drying was concerned.

Pieces of the skin of mice dead of plague were also kept and it was found that they had lost their infecting power after four and six days. In dry organs the pest bacillus soon died. The longest time observed was in pieces of liver kept in sealed glass tubes. Here they lived seven days; after seven days no result was obtained.

Sterilized feces were inoculated with a bouillon culture of plague obtained fresh from a corpse and then saturated with silk threads, wool, and silk fabrics. After drying they were wrapped in sterile filter paper and, inclosed in cotton, were packed in a box and kept in the laboratory at about 29° C. After four days the pest bacillus was alive on all the test objects. After six days only in the wool and after eight days dead in all.

The energetic drying in the desiccator over sulphuric acid hastened the death of the organism.

On account of the great importance of this question, several more tests were made, at lower temperatures, by the committee after its return to Germany. It was there possible, on account of the more favorable laboratory conditions, to make cultures as well as inoculations into mice in order to establish the life and death of the bacillus. The bacillus was kept alive in a room at 15° to 18° C. for twenty-eight days. After thirty-three days no more growth was obtained. Even after twenty-four days the growth was very sparse. The pathogenicity for mice died out much quicker after eighteen days.

"Apparently then the bacillus pestis is very sensitive to rapid and energetic drying as occurs by higher temperatures and in the desiccator.

"Slower drying at lower temperatures is much less deadly. In the climate of Germany, therefore, a rapid death of the organism in fabrics, etc., is not to be expected, as occurs in the tropics. In the hot countries no live bacilli were found in the dust."

EDUARDO GERMANO (*a*) made many observations to determine this question. He worked with a culture from the Breslauer Hygienic Institute obtained through Kral, and which had been grown through many generations in vitro. He used bouillon suspensions of agar cultures and exposed the infected objects in Petri dishes at room temperature, 16° to 20° C.

Room dust mixed with an emulsion of plague bacilli.

Time.	Moist.	Dry.	Dried over sulphuric acid.
1 day	—	—	—

---

[a] Die Uebertragung von Infectionskrankheiten durch die Luft. Dr. Eduardo Germano. Zeitschrift fur Hygiene, Vol. XXVI, 1897; 281.

Fine sand mixed with emulsion of plague bacilli.

Time.	Moist.	Dry.	Dried over sulphuric acid.	Time.	Moist.	Dry.	Dried over sulphuric acid.
1 day	x	(*a*) x	—	20 days	x	—	—
5 days	x	—	—	25 days	x	—	—
5 days	x	—	—	30 days	x	—	—
8 days	x	—	—	40 days	x	—	—
12 days	x	—	—	50 days	x	—	—
16 days	x	—	—	60 days	(*b*) x	—	—

NOTE.—X indicates growth. — indicates no growth.
a The dust is not yet dry.
b The number of colonies is diminished at least to the $\frac{1}{10}$ part of the original.

Loam (Humus boden) mixed with emulsion of plague bacillus.

Time.	Moist.	Dry.	Over H_2SO_4.	Remarks.
1 day	x	—	—	
3 days	x			
5 days	x			
8 days	x			
12 days	x			
16 days	x			
20 days	x			
25 days	x			
30 days	x			
40 days	x			
50 days	x			
60 days	x			

NOTE.—x indicates growth. — indicates no growth.

Tufa (Tuff boden) rubbed up with plague bacillus.

Time.	Moist.	Dry.	Over H_2SO_4	Remarks.
1 day	x	—	—	
5 days	x			
8 days	x			
12 days	x			
16 days	x			
20 days	x			
25 days	x			
30 days	x			
40 days	x			
50 days	x			
60 days	x			

NOTE.—x indicates growth. — indicates no growth.

Marly loam (Löss) rubbed up with plague bacillus.

Time.	Moist.	Dry.	Over H_2SO_4.	Remarks.
1 day	x	—	—	
3 days	x			
5 days	x			
8 days	x			
12 days	x			
16 days	x			
20 days	x			
25 days	x			
30 days	x			
40 days	x			
50 days	x			
60 days	x			

NOTE.—x indicates growth. — indicates no growth.

Brick dust mixed up with plague bacillus.

Time.	Moist.	Dry.	Over H_2SO_4.	Remarks.
1 day	x	x	—	
3 days	x	—		
5 days	x			
8 days	x			
12 days	x			
16 days	x			
20 days	x			
25 days	x			
30 days	x			
40 days	x			
50 days	x			
60 days	x			

NOTE.—x indicates growth. — indicates no growth.

From these tables it follows that the bacillus of plague withstands drying badly, while it remains alive a long time in moist conditions. Only in room dust did it die quickly under moist conditions. After two months, even under moist conditions the number of bacteria were very much diminished. In addition to the test with dust, etc., a series was made with fabrics.

Square pieces of linen, wool, silk, and filter paper (1 cm. square) were sterilized and saturated with a bouillon emulsion of culture. They were placed in Petri dishes and were exposed in the desiccator and in the room. Those that were to remain moist were placed in test tubes in the moist chamber.

The results were as follows:

Linen.

Time.	Moist.	Dry.	Over H_2SO_4	Time.	Moist.	Dry.	Over H_2SO_4.
1 day	x	x		20 days	x		
3 days	x			25 days	x		
4 days	....	o		30 days	x		
7 days	x			40 days	x		
12 days	x			50 days	x		
16 days	x			60 days	x		

NOTE.—x indicates growth. — indicates no growth.

Wool.

1 day	x	x		20 days	x	x	x
3 days	x			25 days	x	x	x
4 days	x	x		30 days	x	x	
8 days	x	x		40 days	x		
12 days	x	x		50 days	x		
16 days	x	x		60 days	x		

NOTE.—x indicates growth. — indicates no growth.

Silk.

1 day	x	x	x	20 days	x		
3 days	x	x	x	25 days	x		
4 days	....	x	x	30 days	x		
8 days	x	—		40 days	x		
12 days	x	....	—	50 days	x		
16 days	x			60 days	x		

NOTE.—x indicates growth. — indicates no growth.

Filter paper.

Time.	Moist.	Dry.	Over H_2SO_4.	Time.	Moist.	Dry.	Over H_2SO_4.
1 day	x	x	x	20 days	x		
3 days	x	....	—	25 days	x		
4 days	x	x		30 days	x		
8 days	x			40 days	x		
12 days	x			50 days	x		
16 days	x			60 days	x		

NOTE.—x indicates growth. — indicates no growth.

It is seen, therefore, that the pest bacilli remain on fabrics quite a long time. In this respect it resembles the bacillus typhosus.

He draws the following conclusions: The pest bacillus has little resistance against drying. It can, therefore, not easily be carried in the dust or air. It is, therefore, not likely, if not impossible, that the disease is spread in the air. However, it may often occur that infection takes place through contact because the organism lives when not wholly dried. Therefore, infected clothing may be very dangerous.

V. DE GIAXA and B. GOSIO, (*a*) made experiments in a small chamber partially ventilated and lighted, having a temperature varying from 10° to 18° C.

Strips of different fabrics, linen or wool, were infected after steam sterilization, and then suspended free or in small cabinets protected from the atmospheric dust. Some of the material was placed on large pieces of the same fabrics arranged so as to simulate a package.

The material of infection was deposited on the cloth either by rubbing with fresh agar-agar culture, in which case small particles of agar in addition to the germs adhere to the texture, or by the direct application of pus or blood from plague-infected animals.

The longest period of observation was thirty days; at the end of that time germs of plague were obtained from the pieces of cloth. In the case of pieces of cloth impregnated with pus or blood the observation was for twenty-nine days. On these the germs developed either in the open air or on cloth folded and inclosed in a box to simulate clothing packed in a trunk.

Pieces of linen thread were steeped in infected blood and exposed to desiccation in an incubator at an air circulation of 36° to 39° C.

After two, four, and five days several threads were placed in tubes of broth. Those exposed two days to desiccation developed slowly. Of those desiccated for four days, only 1 in 3 remained sterile; all those exposed for five days remained sterile.

Plague-infected blood was spread on a rabbit's skin and allowed to dry for four days. After fifteen days' exposure to a temperature varying from 12° to 16° C. (diffused light) the infected surface was scraped and the scrapings were cultivated. The plague bacillus soon developed.

---

a Richerche sul bacillo della peste bubbonica, etc., Annali d' igiene Sperimentale, 1897, No. 7, page 261.

As regards pathogenic action, the germ exposed to desiccation almost always showed a decided slowness in killing the animal.

EFFECT OF SUNLIGHT ON THE PLAGUE BACILLI.

ALBRECHT and BHON (*a*) exposed peritoneal exudate in a test tube (in August, in Vienna), to direct sunlight for six hours, and could not notice any marked difference in the organism.

ABEL (*b*) found that plague bacilli on cover glasses died after one hour exposure to sunlight at 30° C. (in Hamburg). Controls kept in the dark grew after six hours. Thicker spreads from agar cultures withstood sunning at 30° C., three and one-half hours.

KITASATO (*c*) found that the bacillus was killed at Hongkong in three to four hours' sunning. He used pus from buboes.

WILM (*d*) found them destroyed in four hours' exposure to the sun.

THE GERMAN PLAGUE COMMISSION (*e*) made tests in Bombay in this manner: The various objects (glass, silk threads, wool) were saturated with a virulent agar culture of the bacillus pestis. One-half of the objects were exposed to direct sunlight. The other half were laid away in a dark place for control.

In very thin layers on glass the bacillus was killed in one hour.

In thicker layers on glass they were pathogenic for mice after three hours but not after four hours.

In silk threads they were killed after three hours' sunning.

In wool they were virulent for mice after eight hours.

Other tests were made with well grown agar cultures placed in the sunlight. In one or two hours in the sun they still contained active organisms. After a whole day's sunning they were dead. The cultures are warmed very much in the sun; therefore, other tests were made by placing the agar tube in water and kept in the sun one and one-half hours. At the end of the test the temperature of the water was 39° C. The bacillus was alive and virulent.

The following report of the experiments on the viability of the plague bacillus was published by S. L. RAPPOPORT, (*f*) St. Petersburg. The material used was allowed to soak in bouillon cultures of bacillus pestis in a dark closet for twenty four hours, then exposed for successive days to all the sunlight obtainable, or to dry heat.

---

a Die Peste, Müller and Poch, page 61, Vienna, 1900.

b Zur Kenntnis des Pestbacillus. Centralblatt fur Bakteriologie und Parasitenkunde, etc., Bd. XXI, 1897.

c Preliminary notice of the bacillus of bubonic plague, Hongkong, 1894, July 7.

d Uber die Pestepidemic in Hongkong im Jahre 1896. Hygienische Rundschau, 1897, Bd. VII.

e Loc. cit., page 277.

f Quoted by Walter Wyman, Surgeon-General Marine-Hospital Service, in "The Bubonic Plague," Treasury Department Document No. 2165.